National Aeronautics and Space Administration

Returning to the Moon: NASA's Artemis Missions

Tracy Gill

Lander Ground Operations – Human Lander Systems Program

Kennedy Space Center

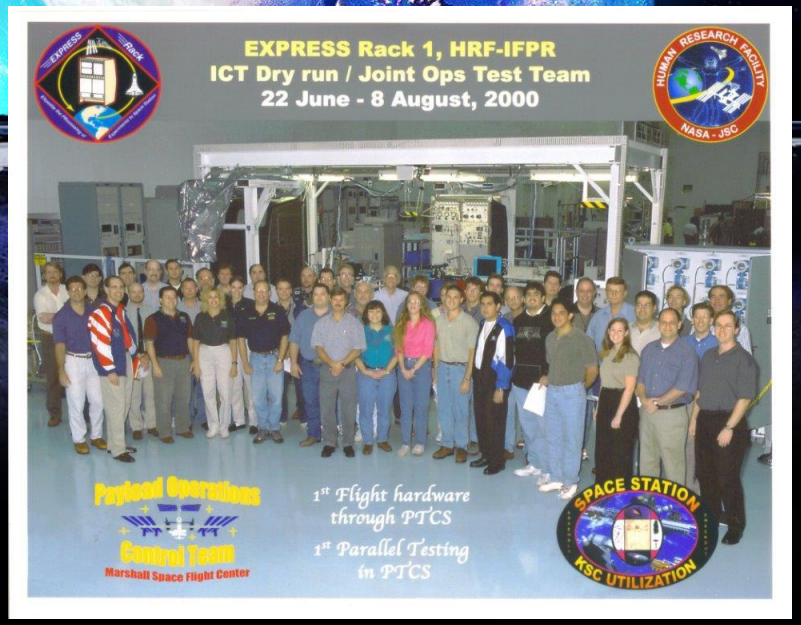
ARTEMIS

My background

- Tracy holds a BS in Electrical Engineering (1989) and an MS in Aerospace and Mechanical Systems (2000) from the University of Florida, an MS in Space Systems from Florida Tech (1994) and is a graduate of the International Space University Space Studies Program in 2006.
- Tracy is a big sports fan following football and basketball and any team that represents the University of Florida. Tracy enjoys speaking to local schools on various topics in the space field and has been an adjunct professor for the International Space University.

NASA "Action" Shots

National Aeronautics and Space Administration

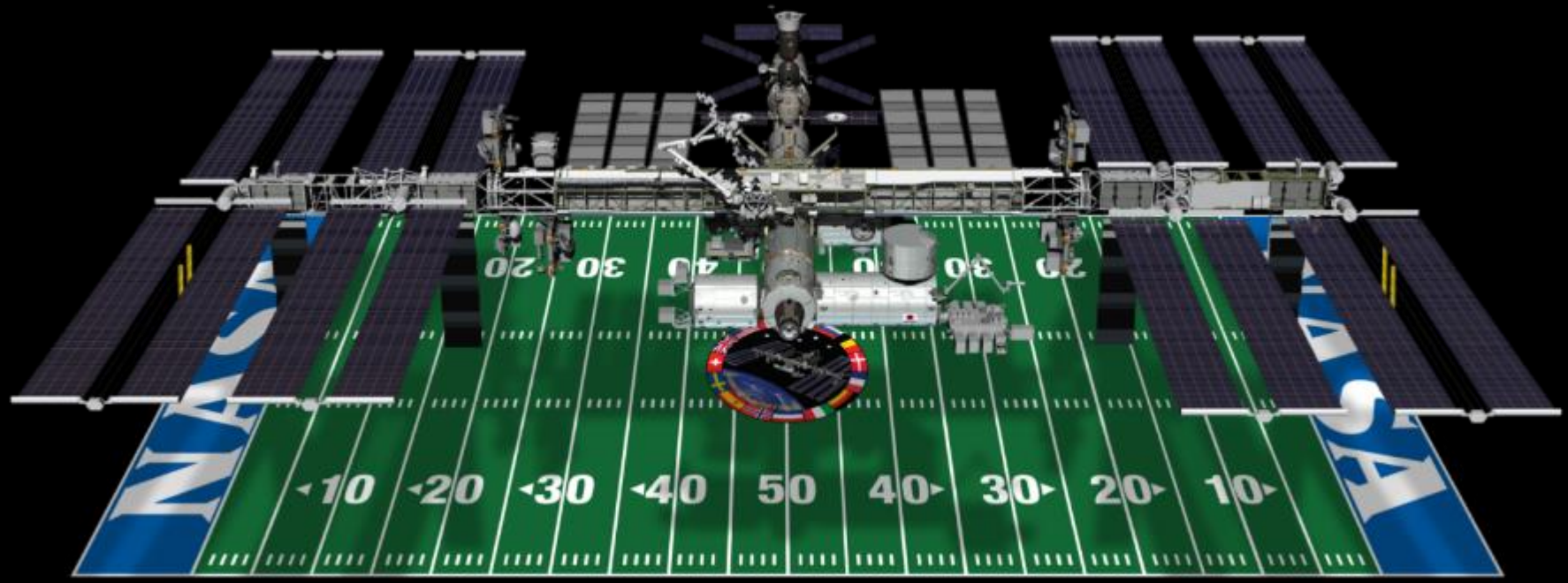


Deep Space Habitats

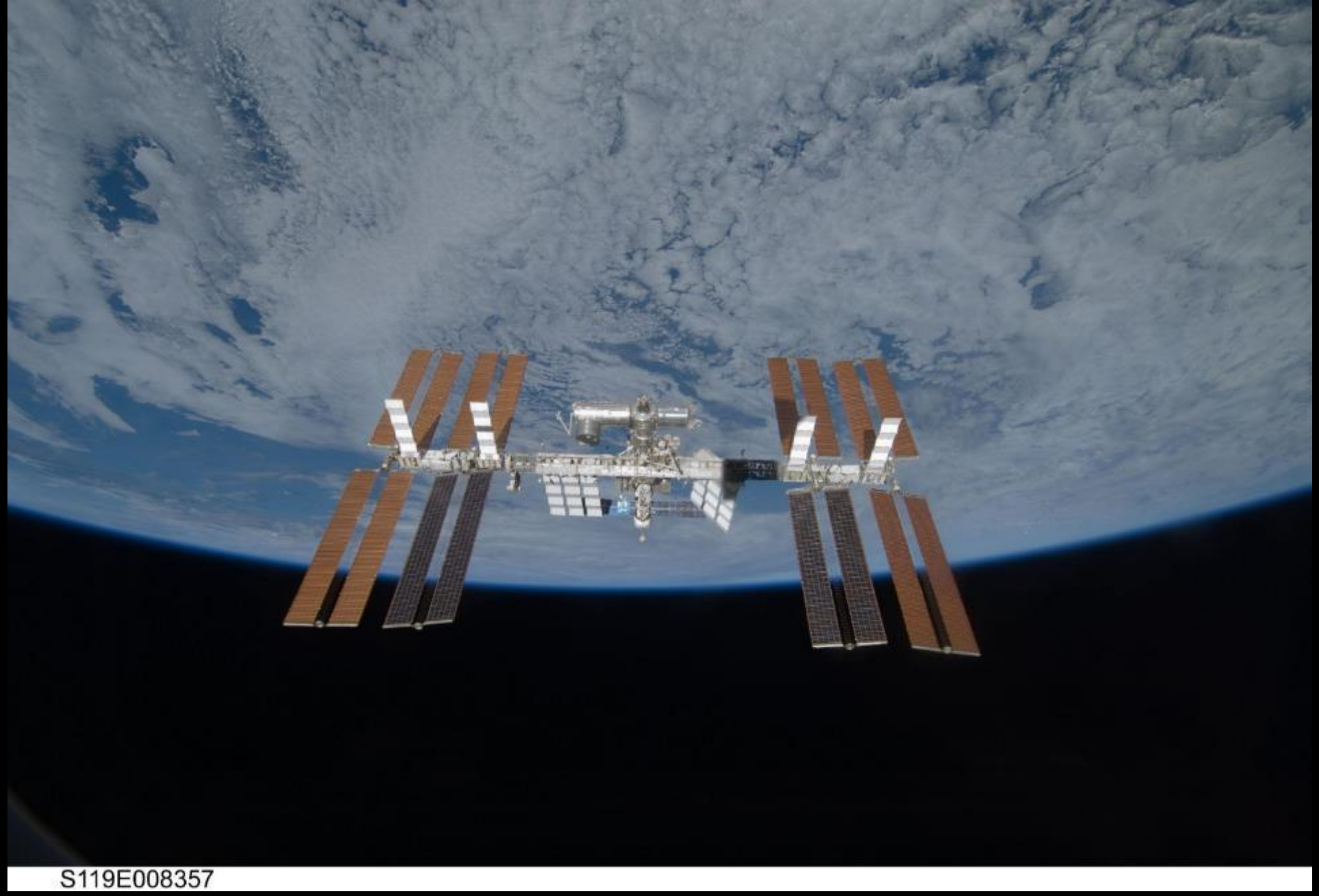
Habitat Demonstration Unit (2011-2013)

Multi-Purpose Logistics Module: Donatello – to be used in NextSTEP Habitat project

INTERNATIONAL SPACE STATION (ISS)



- Spacecraft Mass: +800,000 lb (+362,874 kg)
- Velocity: 17,500 mph (28,200 kph)
- Orbits: 16 times around the Earth/day (~every 90 minutes)
- Altitude: 220 miles above Earth
- Power: 80 kW continuous



See the ISS pass overhead your area! - https://spotthestation.nasa.gov/

S126E008372

ARTEMIS

Twin sister of Apollo and goddess of the Moon in Greek mythology, Artemis is the torch-bringer personifying our path to the Moon. During the next era of human exploration, we will discover life-saving, Earth-changing science and technology along the way.

NASA's goal is to land the first woman and first person of color on the Moon. When the Artemis astronauts land on the lunar surface, they will step into the future, bringing all of humanity with them.

Mission Needs Drive Design

LOW EARTH RETURN

3 HOURS
3,000°F
17,500 MPH
250 MILES

LUNAR RETURN

3 DAYS
5,200°F
24,700 MPH
240,000 MILES

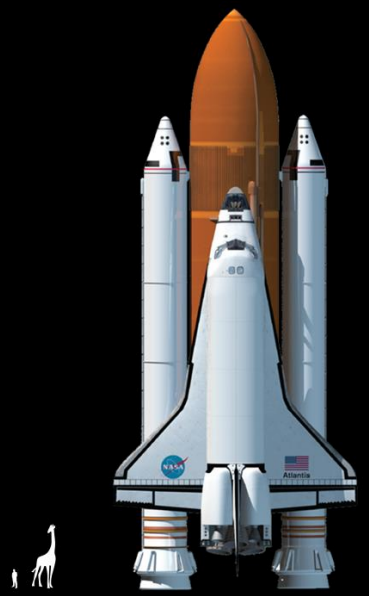
MARS RETURN

9 MONTHS
6,200°F
26,800 MPH
39,000,000 MILES

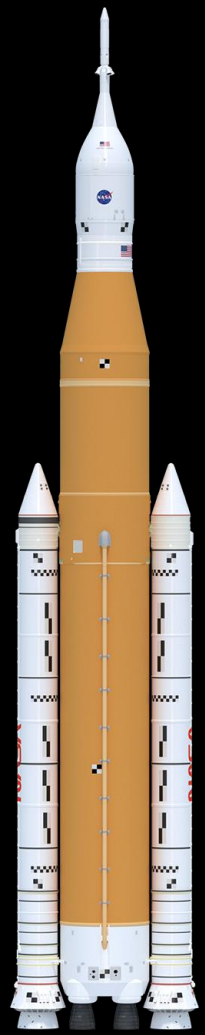
*Numbers are averages


United States
SLS

STATUE OF LIBERTY
305 ft.



SPACE SHUTTLE
184 ft.

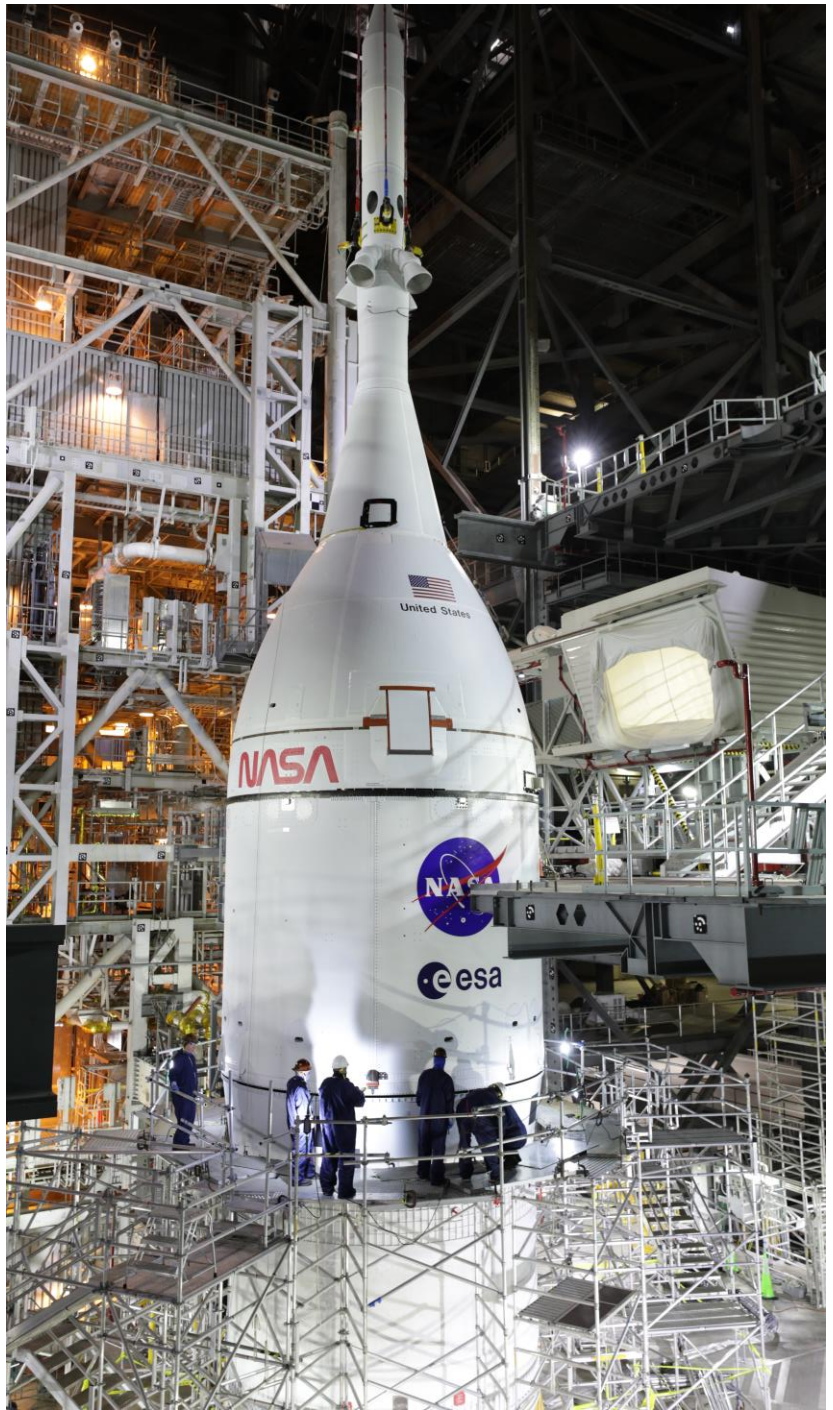


SLS / ORION Block I
322 ft.

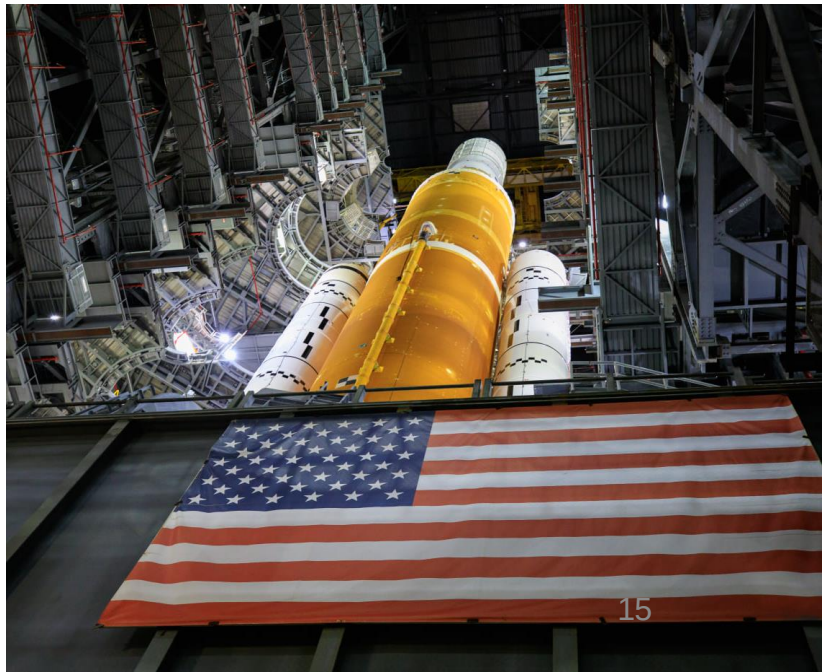
SLS / ORION Block II
364 ft.

SATURN 5
363 ft.


Spacecraft Adapter Jettison Panels
ORION
Crew Module (CM)
Launch Abort System
Abort Motor
Jettison Motor
Attitude Control Motor
Spacecraft Adapter
Service Module (SM)
Includes the European Service Module and the NASA Crew Module Adapter


United States
NASA
esa

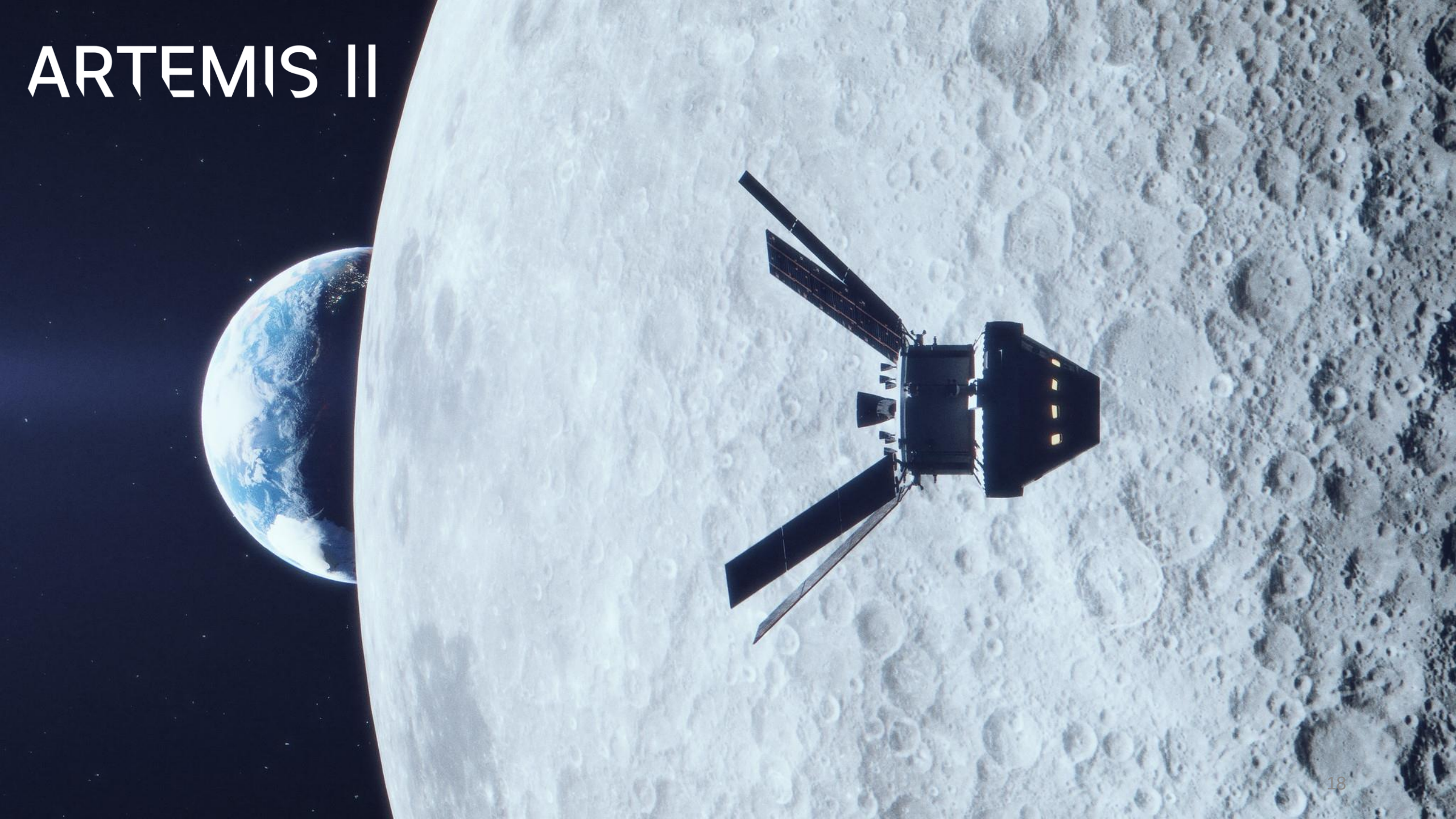

NASA
esa



Artist Concept

ARTEMIS I

ARTEMIS II




Kayla
BARRON
Matthew
DOMINICK
Warren
HOBURG
Christina H.
KOCH
Joseph
ACABA
Raja
CHARI
Victor
GLOVER
Jonny
KIM
Kjell
LINDGREN
Anne
McCLAIN
Jasmin
MOGHBELI
Frank
RUBIO
Jessica
WATKINS
Nicole A.
MANN
Jessica
MEIR
Kate
RUBINS
Scott
TINGLE
Stephanie D.
WILSON

ARTEMIS III

HLS

Initial Human Landing System

Image Credit: SpaceX


GATEWAY
NASA
CSA ASC
esa
JAXA

ARTEMIS BASE CAMP

Comm, Nav, Power

Surface Habitat

In-Situ Resource Utilization (ISRU)

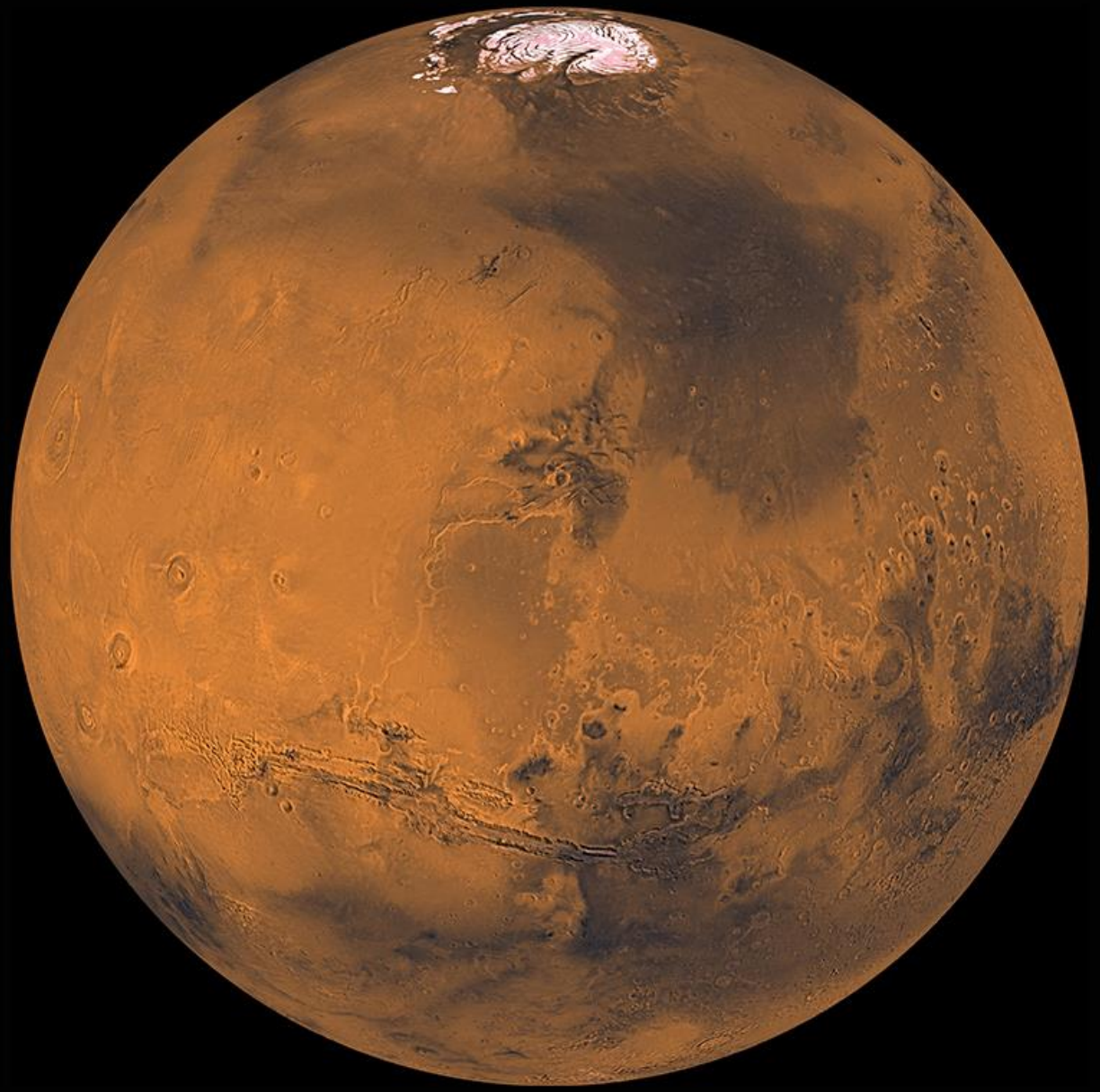
Pressurized Rover

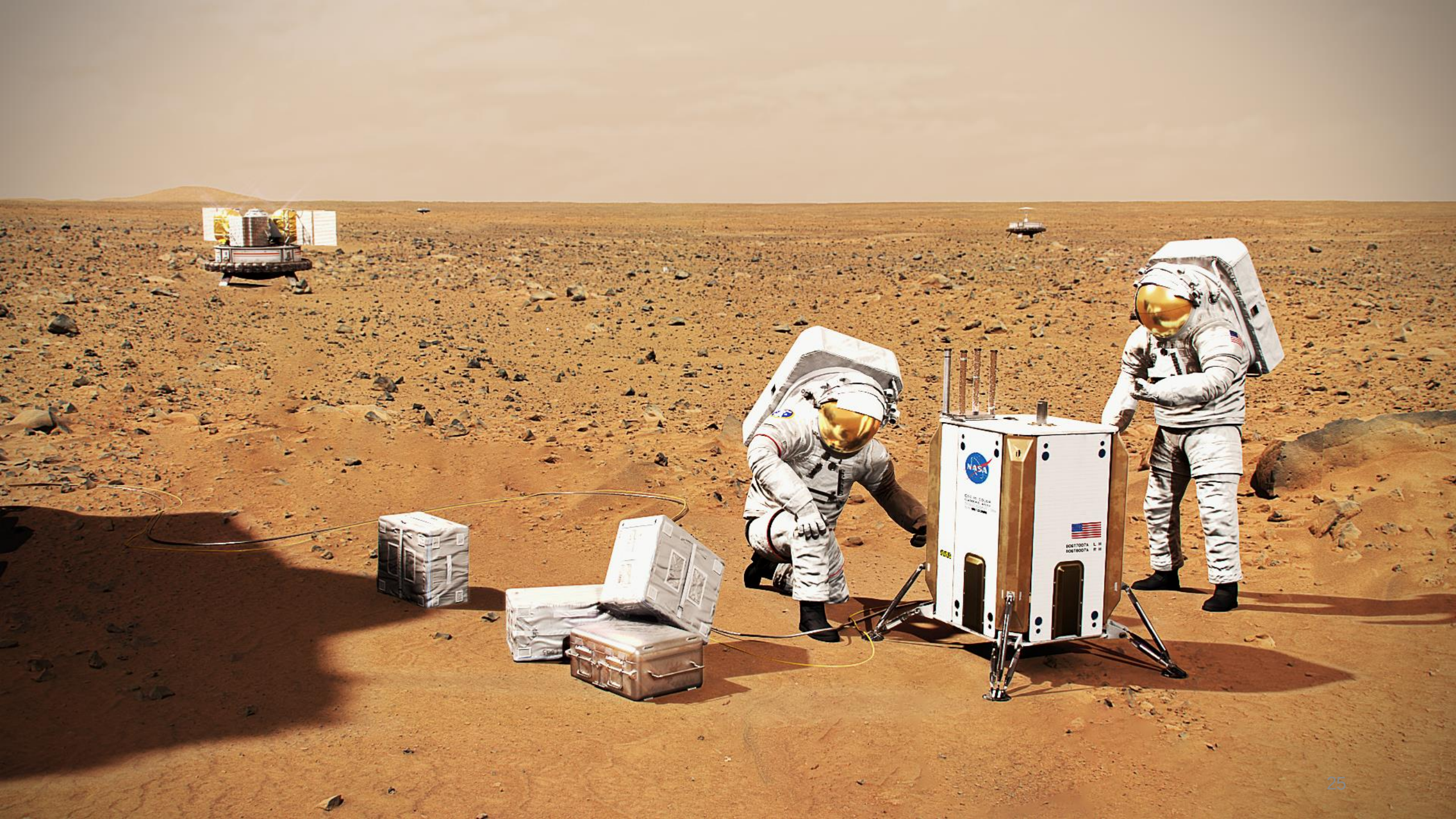
Human Landing System

Spacesuits

Lunar Terrain Vehicle

Artist's illustration of Artemis Base Camp





Taking the Next Giant Leap

Humans on Mars

Moon Hoax? – No way!

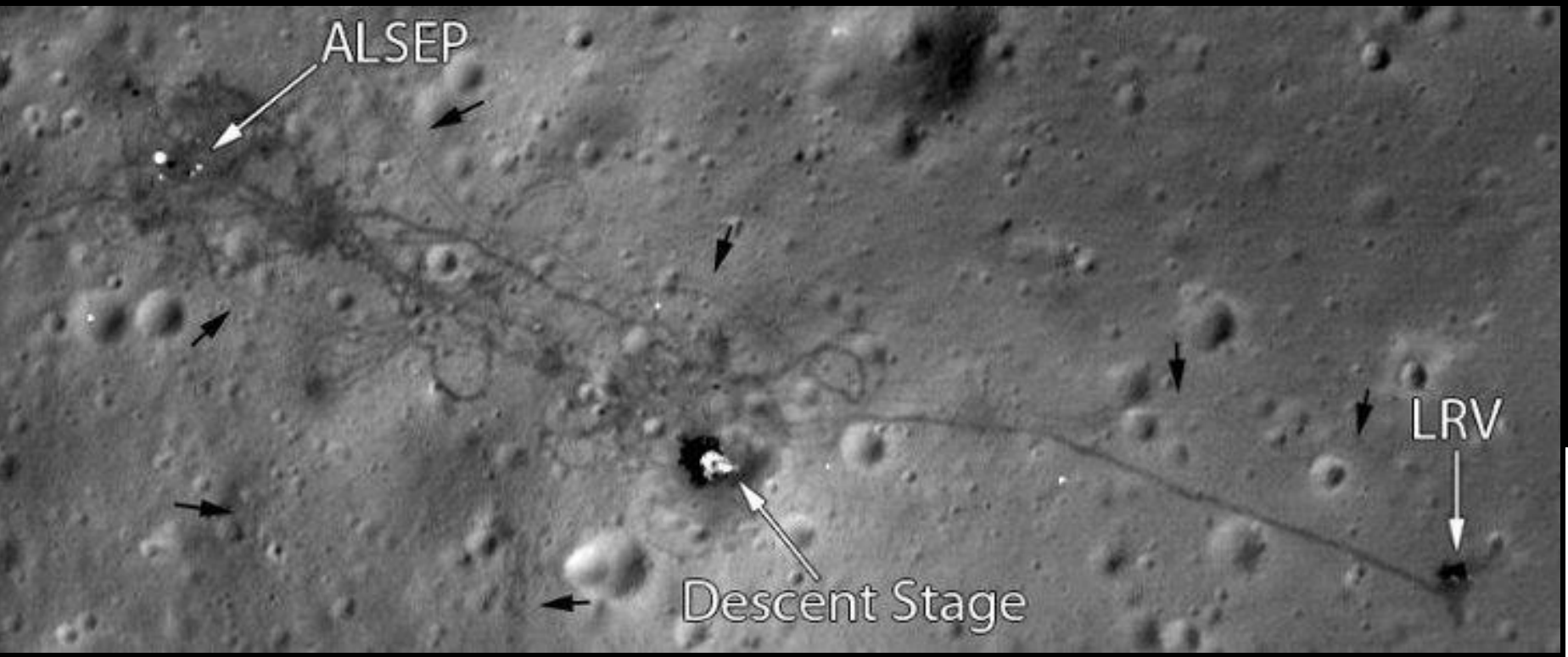
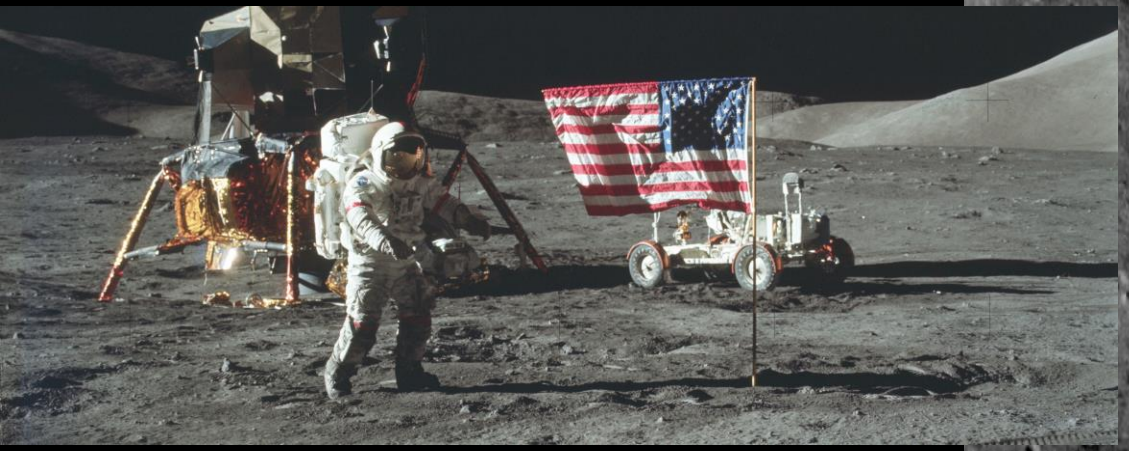


Image of the Apollo 15 landing site from the NASA/Lunar Reconnaissance Orbiter

Apollo 15 image from the lunar surface



Apollo 17 Landing Site
LROC NAC M168000580LR
Low Periapse orbit

100 meters

ALSEP Equipment

Geophone Rock

Challenger Descent Stage

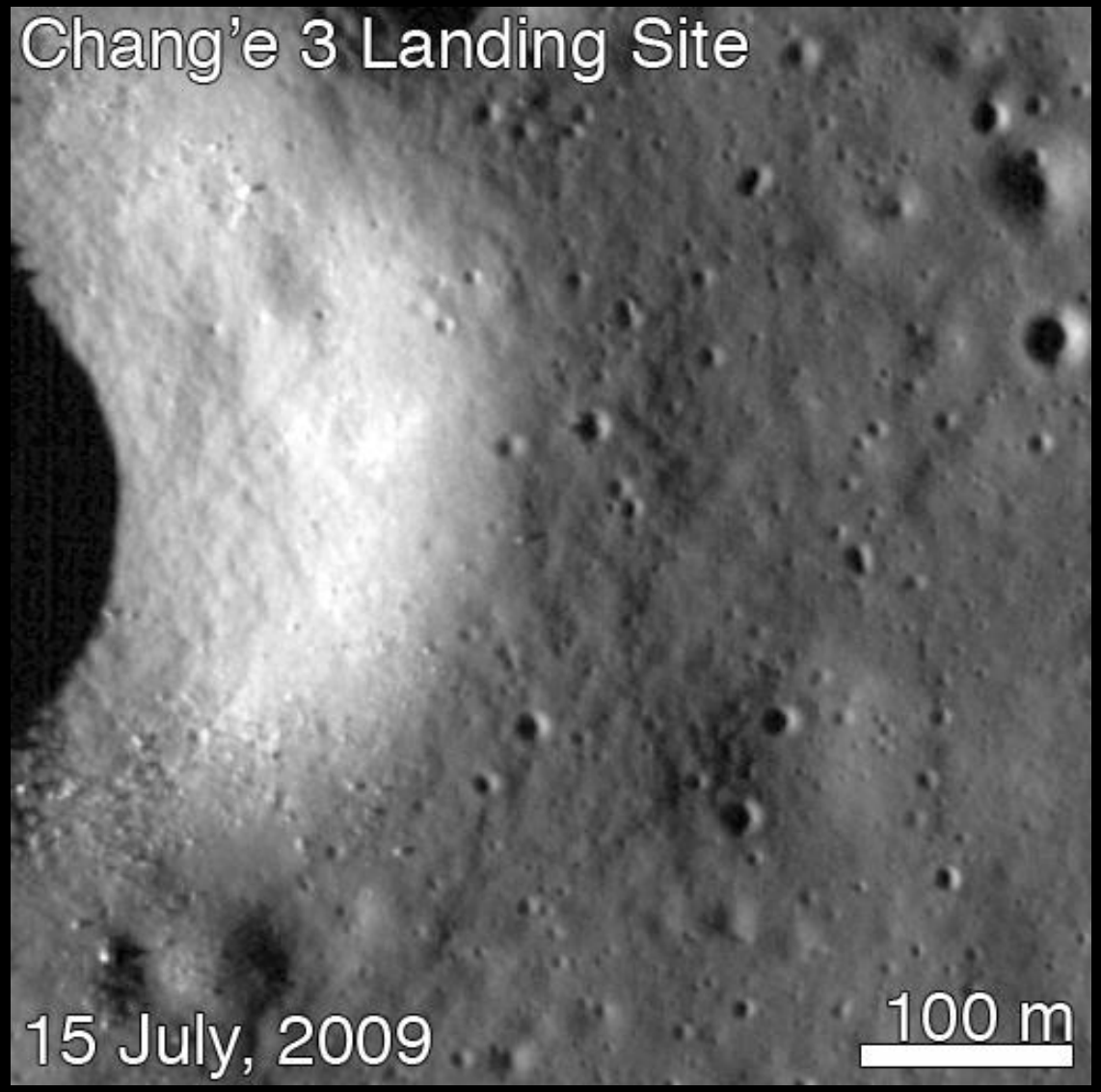
LRV

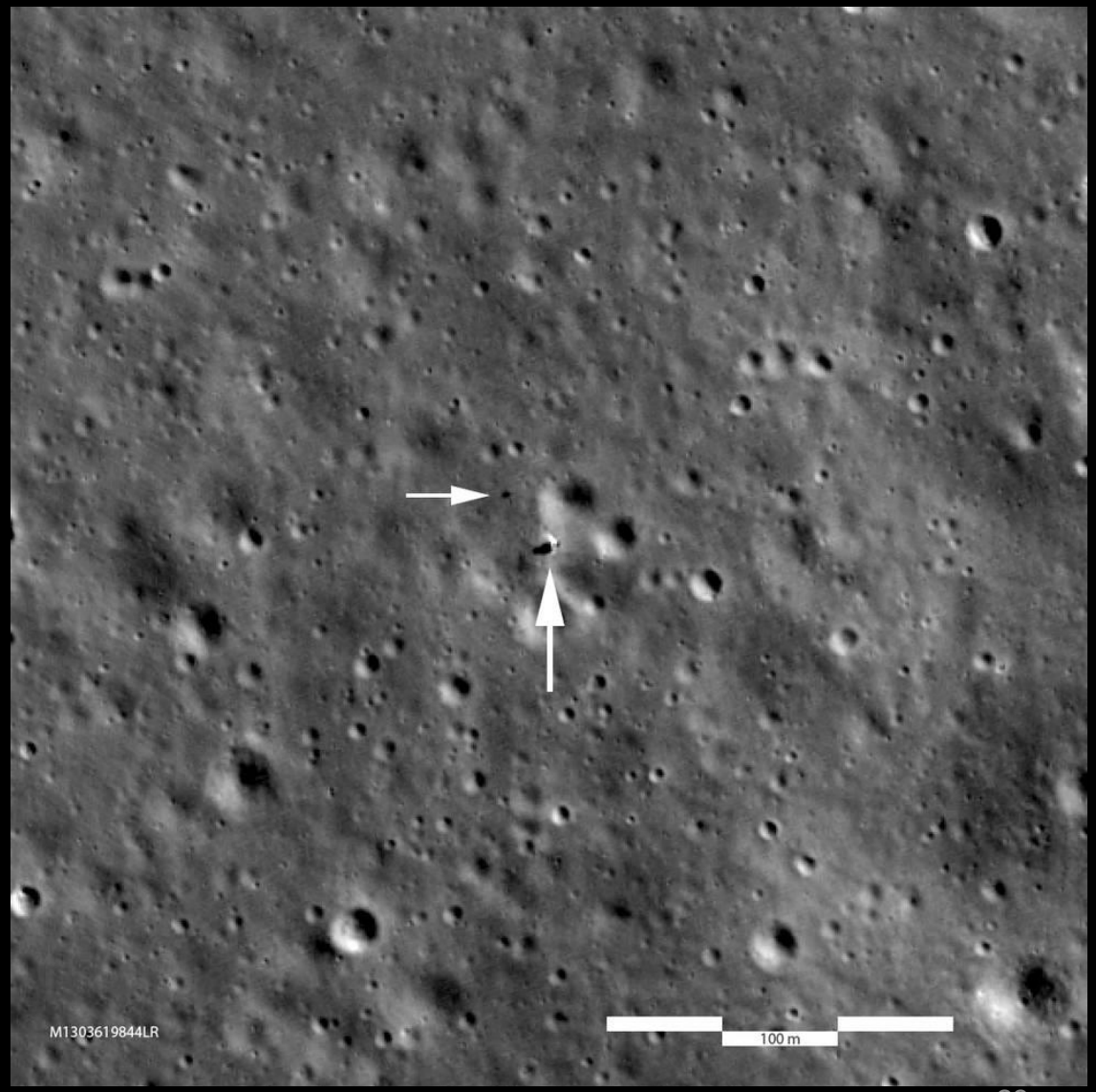
Challenger 3x Enlargement

December 11 1972

Apollo 17 landing Site

Chang’e 4 – Feb 1, 2019





Credit: NASA/Lunar Reconnaissance Orbiter

Other good information…

- NASA Tournament Lab - Challenges and opportunities for the public to solve problems and analyze data
- NASA 3D objects - You can make 3d prints of NASA systems or use them in modeling software tools
- NASA X-Hab Grant Program – NASA advised projects using systems engineering process
- **NASA Solicitation and Proposal Integrated Review and Evaluation System – host site for most every NASA solicitation opportunity**

Observations

- Grad School
  - Be sure that you want to pursue specialization in a field via an advanced degree or perhaps get some experience before deciding if not sure
  - If you're working, you can probably get your employer to at least partially pay for grad school!
- Project based activity experience
  - Working on racecars, robot competitions, concrete canoes, etc. where a multidiscipline team works together on a timeline and on a budget are the best kinds of experience to have in high school and college to prepare you for the work environment
- Find problems that need to be solved and solve them proactively
  - Can be fun and usually gives you some latitude in how to solve
- Find work that you want to do. You'll do a better job and have a better life if you enjoy what you do
- My mission - aim for being one of the most productive people in my field and for being someone with whom other people want to work.
- If we're landing on the moon in the next few years, it's going to be hard to get me to retire!

Challenges

- Doing hard things, the unknown, pushing exploration
- Intellectual Property
- Export Control – how we protect sensitive technical information from foreign intelligence
- Distributed teams – across the country and the world
- Limited Resources and time

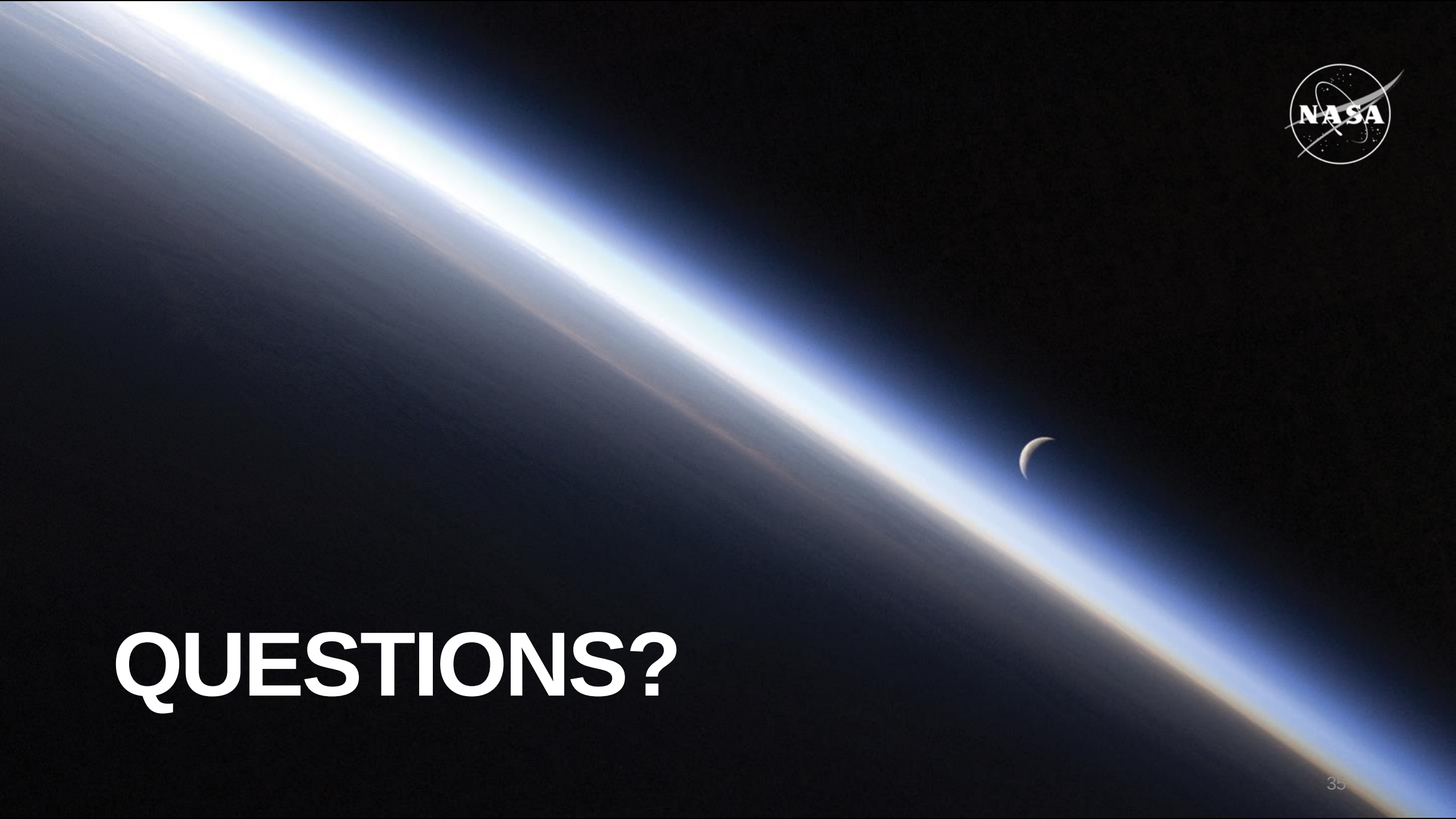
Tools – how do we do the work we do

Examples of some of the tools we use in our daily work

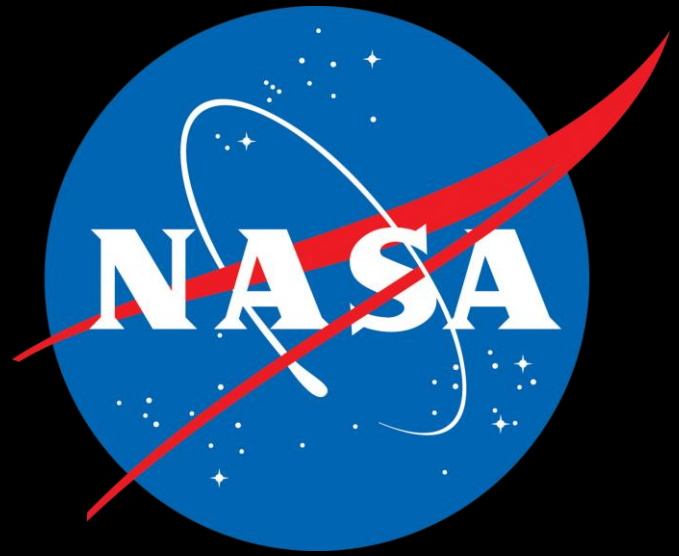
- Virtual teams across the United States and the world
  - Travel, Video Conference (e.g. Vidyo), Teleconference, Desktop Sharing (e.g WebEx, Skype)
- Microsoft SharePoint for collaboration, documentation, archiving, schedule integration, status
- Productivity Tools – Outlook with secure features, PowerPoint, Excel, Word
- Modeling and Simulation using Maya, MATLAB, Simulink, Unity, etc.
- Design tools – Pro-E, AutoCAD
- Secure cell phones

Solving Problems and Getting Results

- Approach
  - Build, test, learn is usually the fastest way to make progress rather than overanalyzing – 3D printing, machine shops, prototyping labs, analog tests
- Resources
  - Budget – you never have as much as you want. Drives innovation
  - Information - Archives, Lessons Learned, Internet tools
  - Collaborators - People are the best resource. People are everywhere and you need their help to succeed! You can't do much of anything without a team.
  - Partners - schools, universities, companies small and large.
- Recording lessons, findings
  - Technology Transfer - https://technology.nasa.gov/
  - NASA Technical Report Server - https://www.sti.nasa.gov/

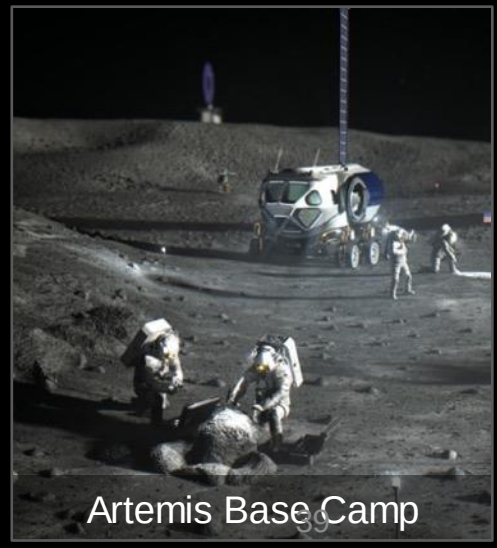

QUESTIONS?


ARTEMIS

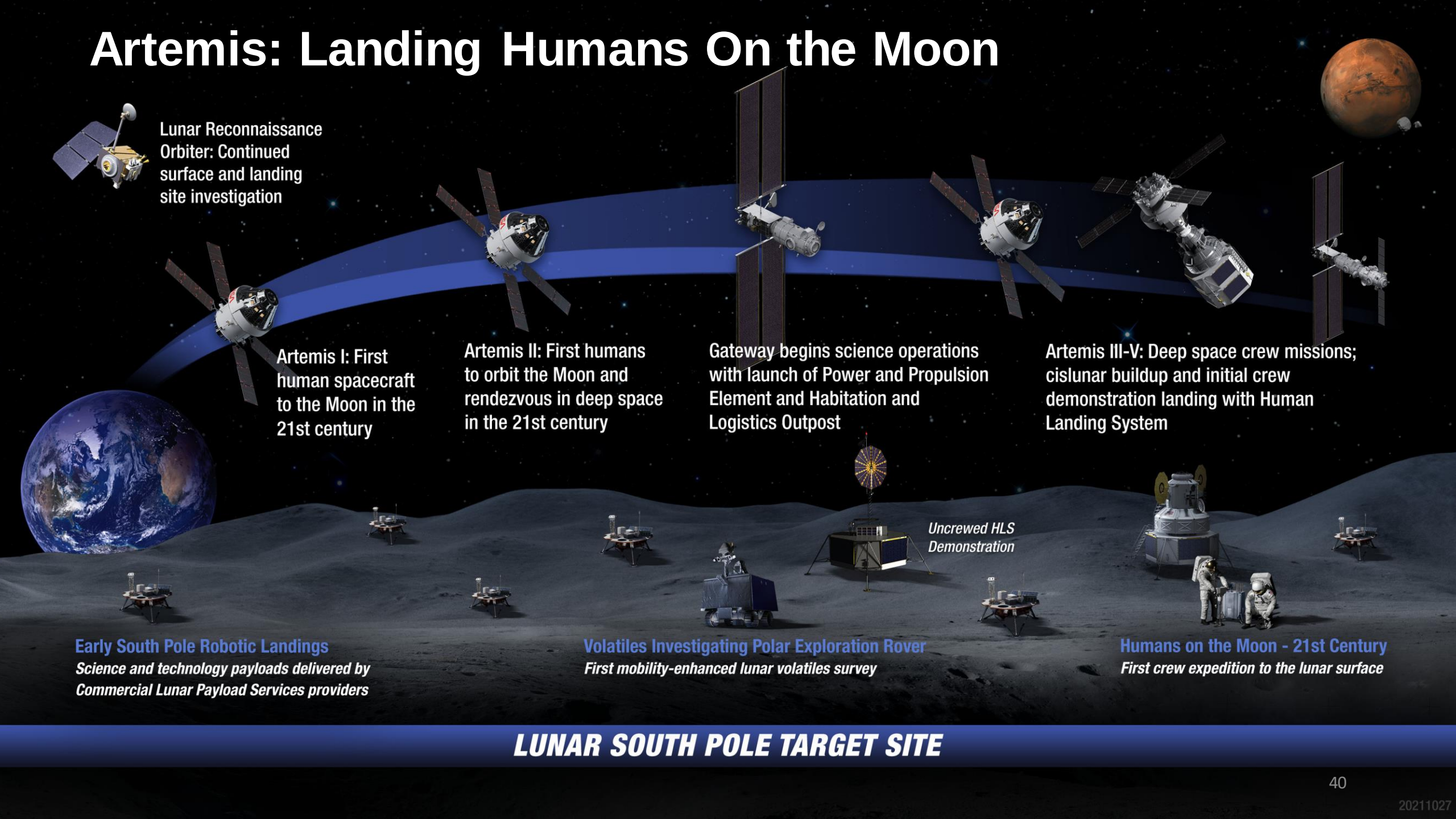


Back Up Slides and Supplemental Resources

Artemis: a Foundation for Deep Space Exploration

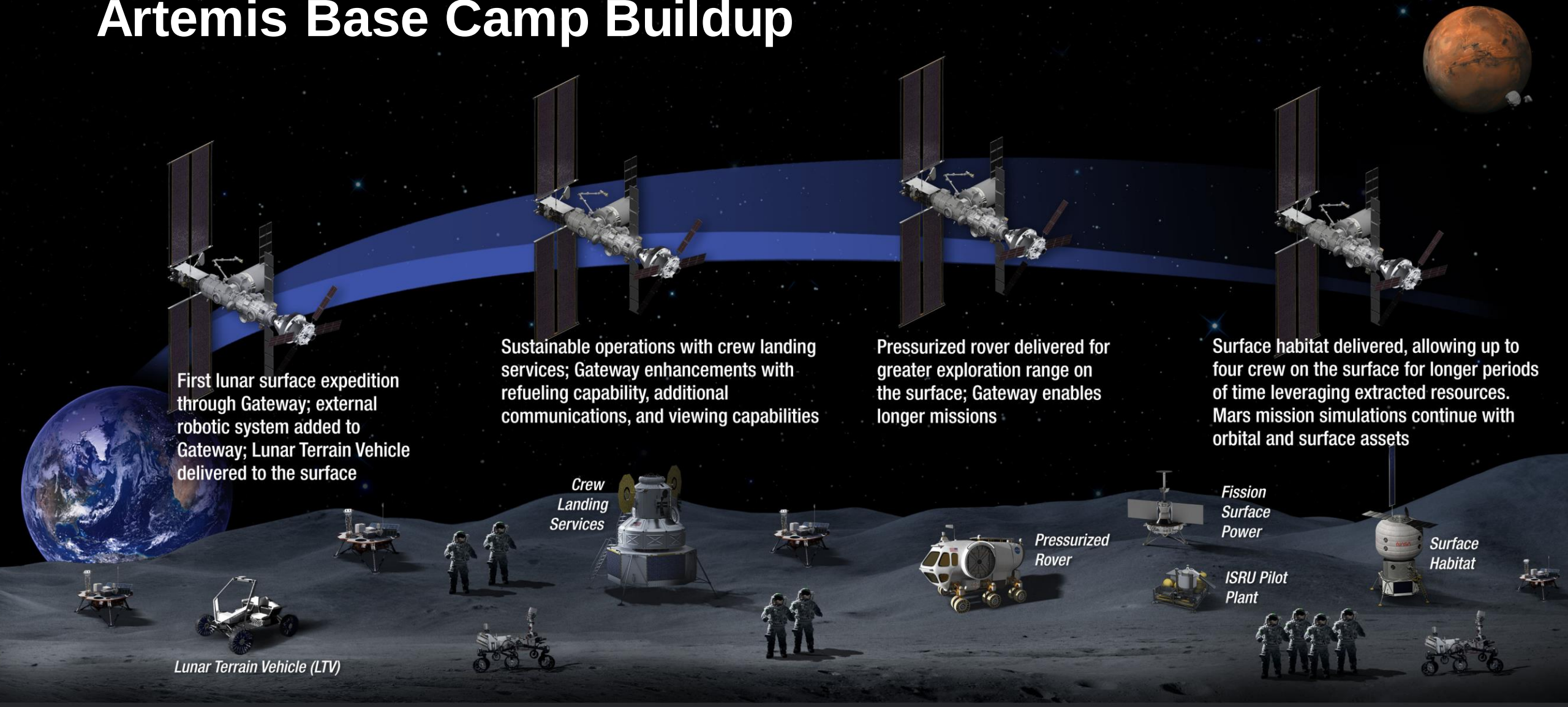


Artemis: Landing Humans On the Moon



LUNAR SOUTH POLE TARGET SITE

Artemis Base Camp Buildup



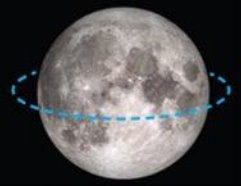
SUSTAINABLE LUNAR ORBIT STAGING CAPABILITY AND SURFACE EXPLORATION

MULTIPLE SCIENCE AND CARGO PAYLOADS | U.S. GOVERNMENT, INDUSTRY, AND INTERNATIONAL PARTNERSHIP OPPORTUNITIES | TECHNOLOGY AND OPERATIONS DEMONSTRATIONS FOR MARS

GATEWAY ORBIT

Cislunar space offers innumerable orbits for consideration, each with merit for a variety of operations. The Gateway will support missions to the lunar surface and serve as a staging area for exploration farther into the solar system, including Mars.

ORBIT TYPES



LOW LUNAR ORBITS

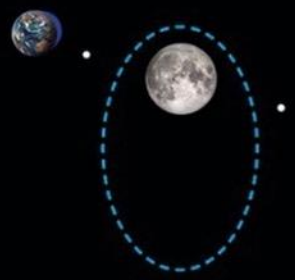
Circular or elliptical orbits close to the surface; excellent for remote sensing, difficult to maintain in gravity well.

» Orbit period: 2 hours

DISTANT RETROGRADE ORBITS

Very large, circular, stable orbits; easy to reach from Earth, but far from the lunar surface

» Orbit period: 2 weeks



HALO ORBITS

Fuel-efficient orbits revolving around Earth-Moon neutral-gravity points

» Orbit period: 1-2 weeks

NEAR-RECTILINEAR HALO ORBIT (NRHO)

ACCESS

Easy to access from Earth orbit with many current launch vehicles; staging point for both lunar surface and deep space destinations

ENVIRONMENT

The deep space environment is useful for radiation testing and experiments in preparation for missions to the lunar surface and Mars

SCIENCE

Favorable vantage point for Earth, sun and deep space observations

COMMUNICATIONS

Provides continuous view of Earth and communication relay for lunar farside

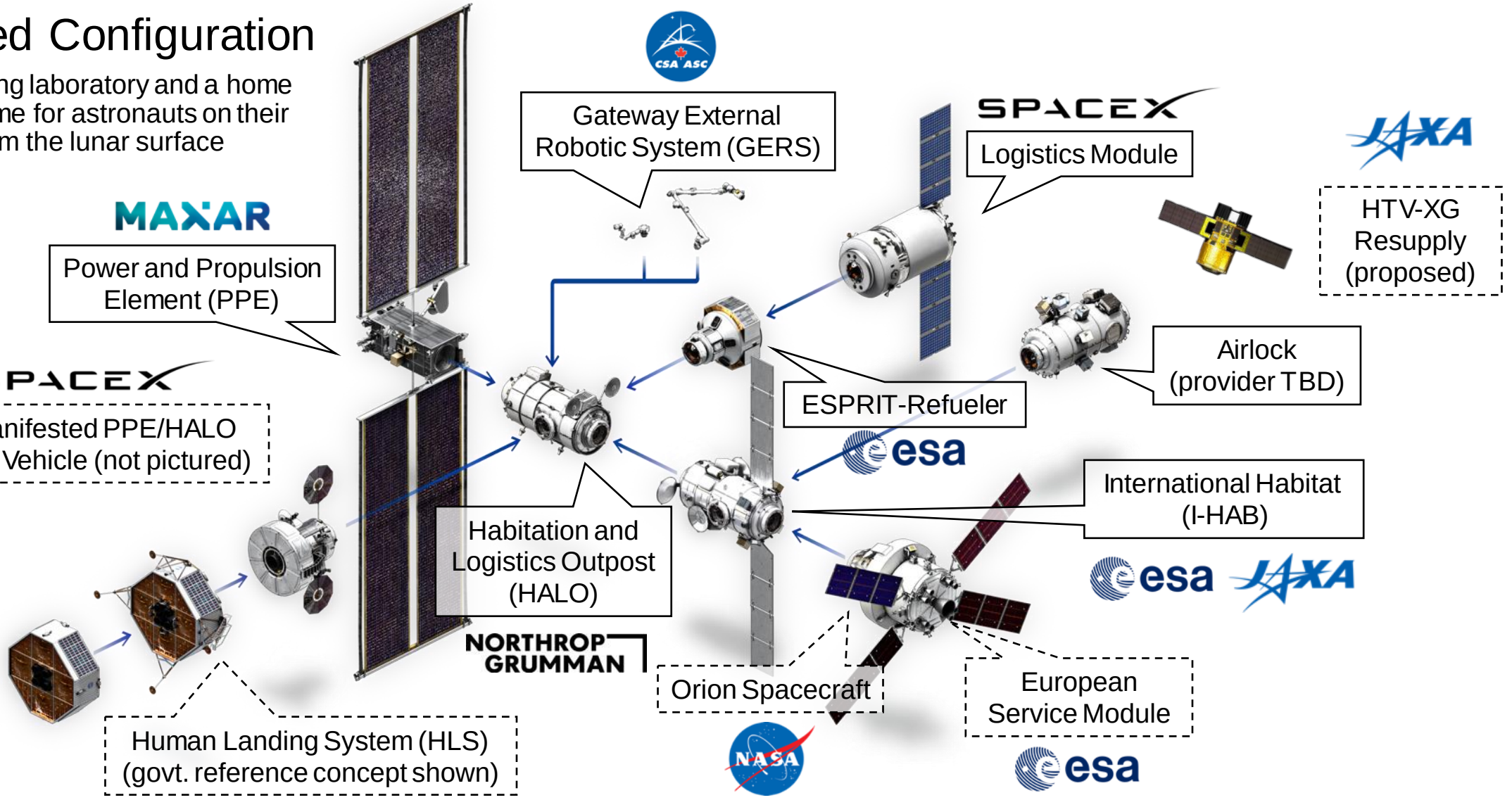
SURFACE OPERATIONS

Supports surface telerobotics, including lunar farside; provides a staging point for planetary sample return missions

GATEWAY

Expanded Configuration

A robust orbiting laboratory and a home away from home for astronauts on their way to and from the lunar surface

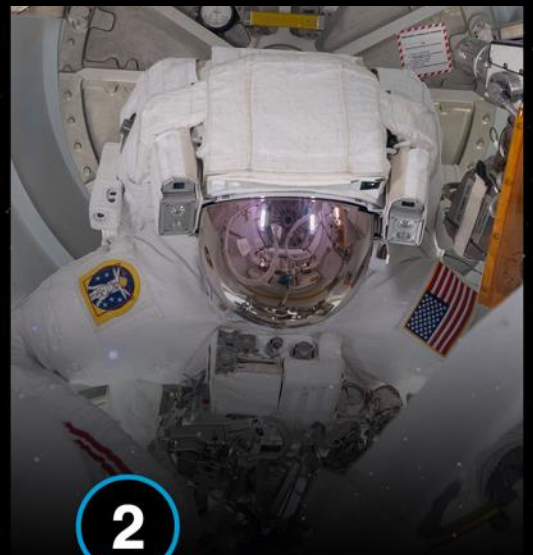



ARTEMIS
ARTEMIS ACCORDS
United for Peaceful Exploration of Deep Space
NASA
ASI
Agenzia Spaziale Italiana
Australian Space Agency
AEB
BRAZILIAN SPACE AGENCY
AGENCY LINKED TO THE MCTI
CSA ASC
JAXA
KARI
한국항공우주연구원
Korea Aerospace Research Institute
LSA
LUXEMBOURG SPACE AGENCY
NEW ZEALAND SPACE AGENCY
POLSA
Polish Space Agency
КОСМІЧНЕ АГЕНТСТВО УКРАЇНИ
وكالة الإمارات للفضاء
UAE SPACE AGENCY
UK SPACE AGENCY

Hazards of Human Spaceflight

1 Space Radiation

Invisible to the human eye, radiation increases cancer risk, damages the central nervous system, and can alter cognitive function, reduce motor function and prompt behavioral changes.

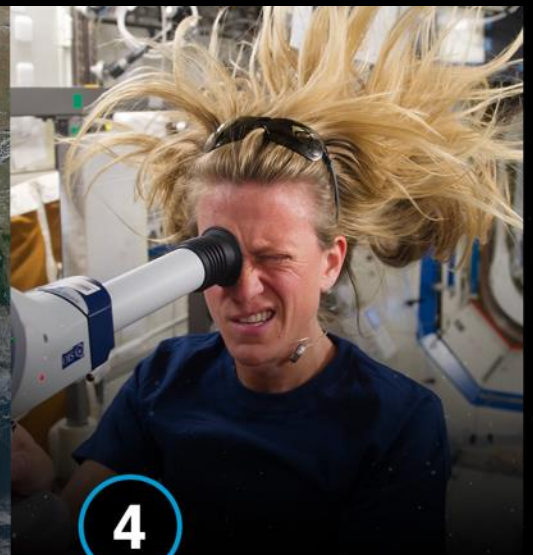


2 Isolation and Confinement

Sleep loss, circadian desynchronization, and work overload may lead to performance reductions, adverse health outcomes, and compromised mission objectives.

3 Distance from Earth

Planning and self-sufficiency are essential keys to a successful mission. Communication delays, the possibility of equipment failures and medical emergencies are some situations the astronauts must be capable of confronting.



4 Gravity (or lack thereof)

Astronauts encounter a variance of gravity during missions. On Mars, astronauts would need to live and work in three-eighths of Earth's gravitational pull for up to two years.

5 Hostile/Closed Environments

The ecosystem inside a vehicle plays a big role in everyday astronaut life. Important habitability factors include temperature, pressure, lighting, noise, and quantity of space. It's essential that astronauts stay healthy and happy in such an environment.

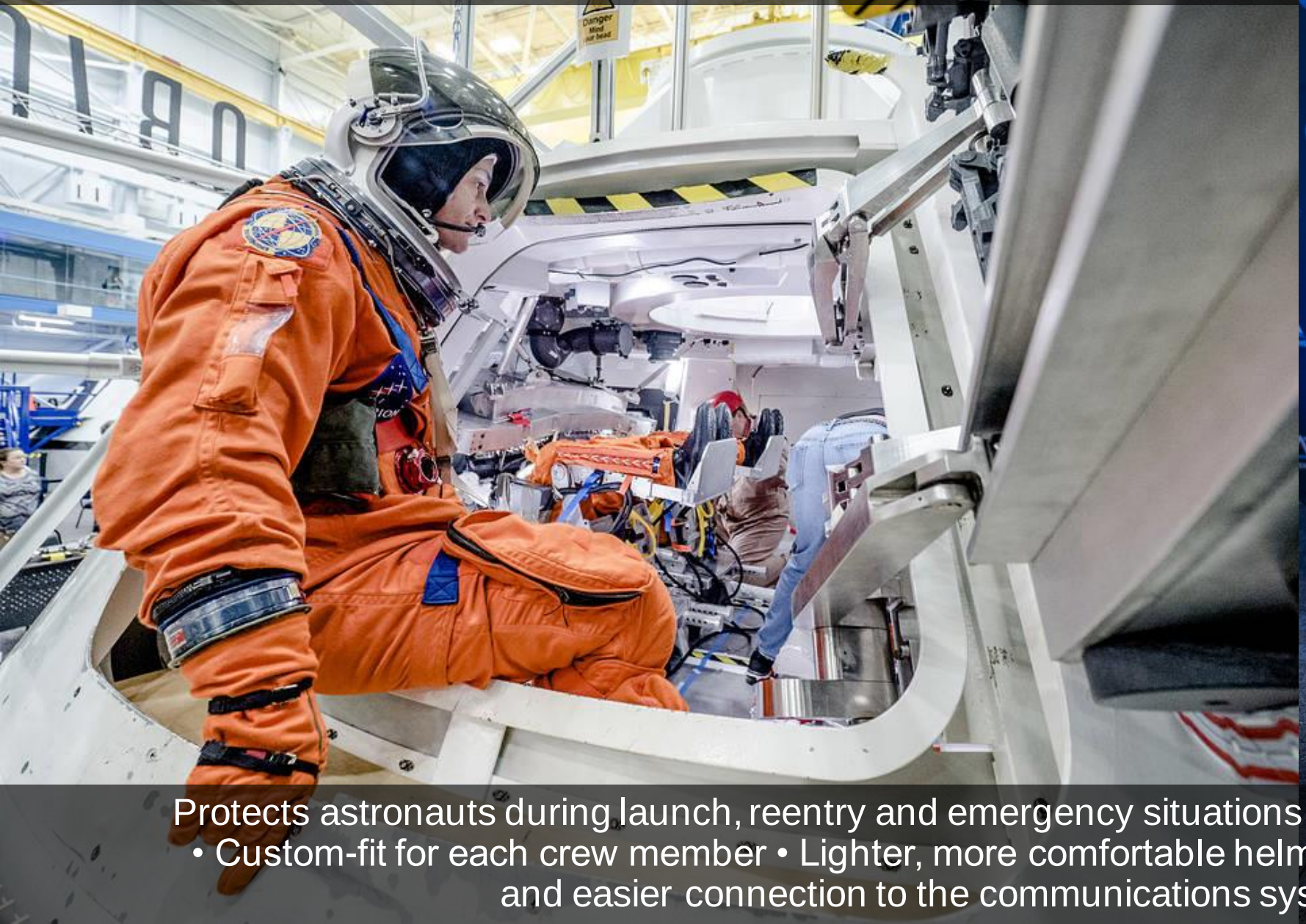
Lunar Terrain Vehicle
Unpressurized Rover

PRESSURIZED ROVER

Commercial Lunar Payload Services

14 CLPS providers are currently on contract and eligible to bid on payload deliveries to the Moon

Orion Crew Survival System



Protects astronauts during launch, reentry and emergency situations during Artemis missions
• Custom-fit for each crew member • Lighter, more comfortable helmet with noise reduction and easier connection to the communications system

Advanced SPACESUITS

- Increased flexibility to enable lunar surface exploration and advanced sample collection
- Increased anthropomorphic range to accommodate a wider range of crew members
- Rechargeable system and life support subsystems enabling high frequency spacewalks and long duration stays on the Moon's surface
- Specialized tools ensure quality samples are collected and returned safely to Earth

Pictured left: Kristine Davis, a spacesuit engineer at NASA's Johnson Space Center, wears a ground prototype of NASA's Exploration Extravehicular Mobility Unit (xEMU)

Bots Before Boots

Robots living and working on Mars today pave the way for smarter, safer human exploration of the lunar south pole

Evolving Habitation Systems for SUSTAINABLE HUMAN EXPLORATION

Use ISS as Testbed for Evolution of ECLSS and CHPS

International Space Station (ISS)

Continue Testbeds on Commercial Platforms in LEO

Notional Commercial Platform in LEO

Infuse Technologies into Gateway

Orion and Gateway

- Toilet
- CO_2 removal
- Environmental monitoring
- Exercise technology
- Radiation protection and monitoring
- Medical system
- Fire suppression and cleanup

Infuse Full Long Duration Microgravity ECLSS and CHPS into Mars Transport

Mars-class Transportation

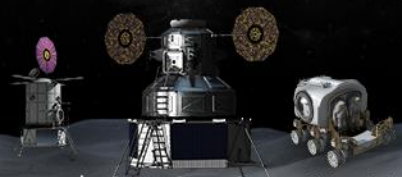
- Highly-reliable regenerative ECLSS from ISS demonstration
- Environmental monitors
- Exploration food system
- Countermeasures
- Medical system
- Radiation protection

Complementary Ground Tests and Analogs

- Food system performance and reliability testing
- CHPS integrated analogs

Human Landing System and Sustained Lunar Surface ECLSS-CHP Infusion

- Partial gravity and exploration atmosphere fire safety
- Exploration spacewalk pre-breathe and conops
- Surface habitat: regenerative ECLSS and CHPS adapted for surface
- Pressurized rover: ECLSS waste collection and transfer



Mars Surface ECLSS-CHPS

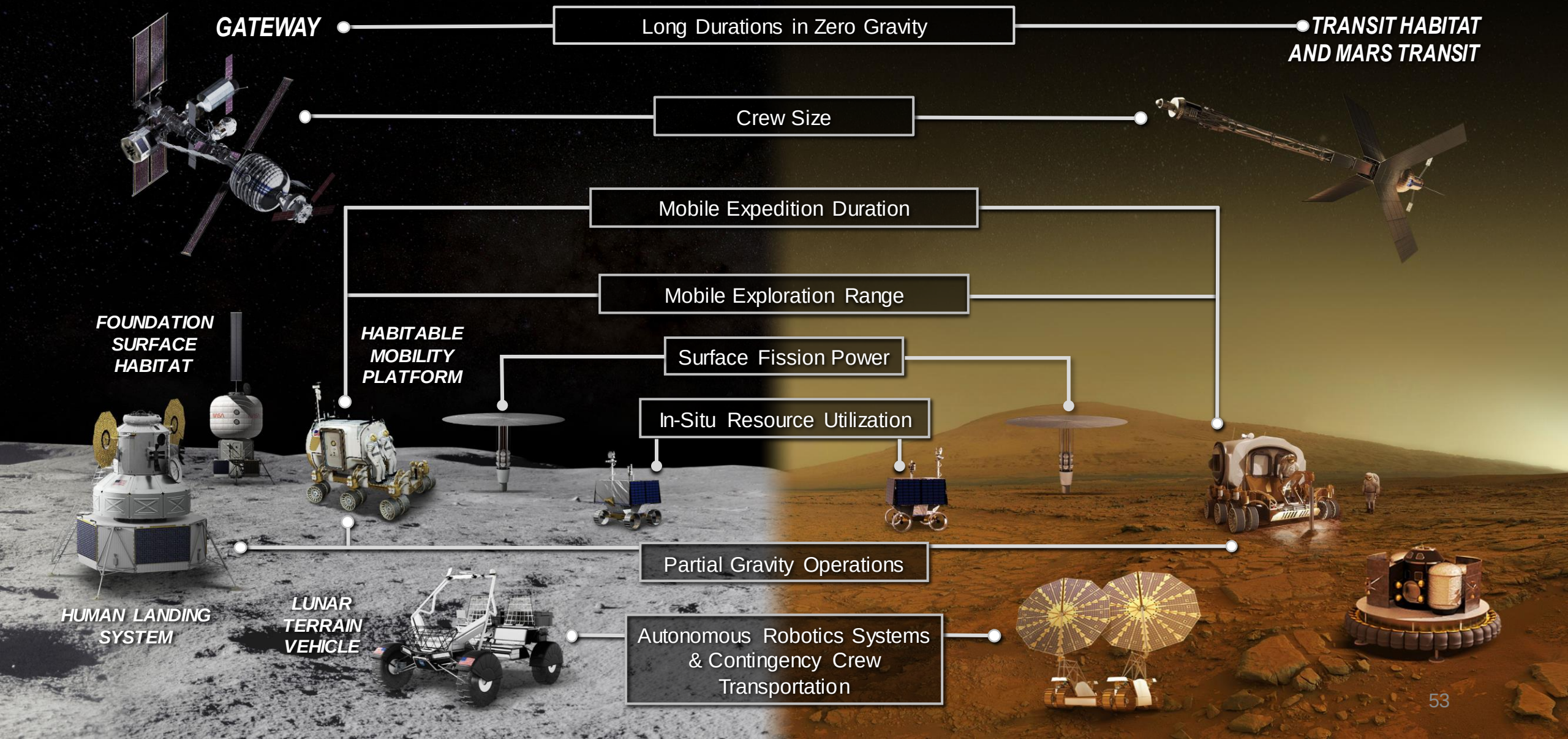
- Robust microbial and chemical monitoring
- Planetary protection compatible waste strategy

ECLSS = Environmental Control and Life Support Systems | CHPS = Crew Health and Performance Systems | LEO = Low-Earth Orbit

GRAPHICS NOT TO SCALE 20210115

MOON AND MARS EXPLORATION

Operations on and around the Moon will help prepare for the first human mission to Mars



NASA has featured 2,000+ spinoff technologies improving life on Earth

Everyone benefits:

Students

Construction Workers

Conservationists

Farmers

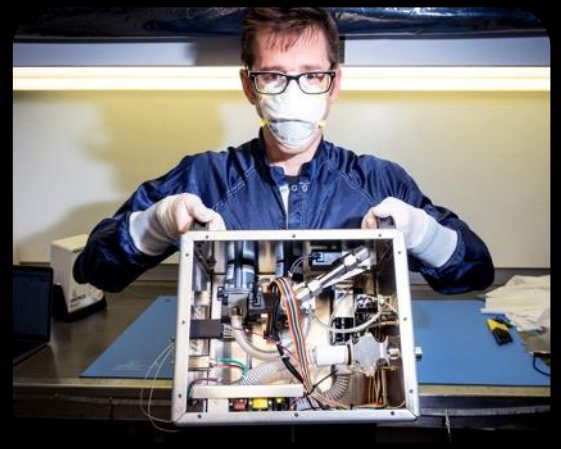
Doctors and Patients

Airplane Passengers

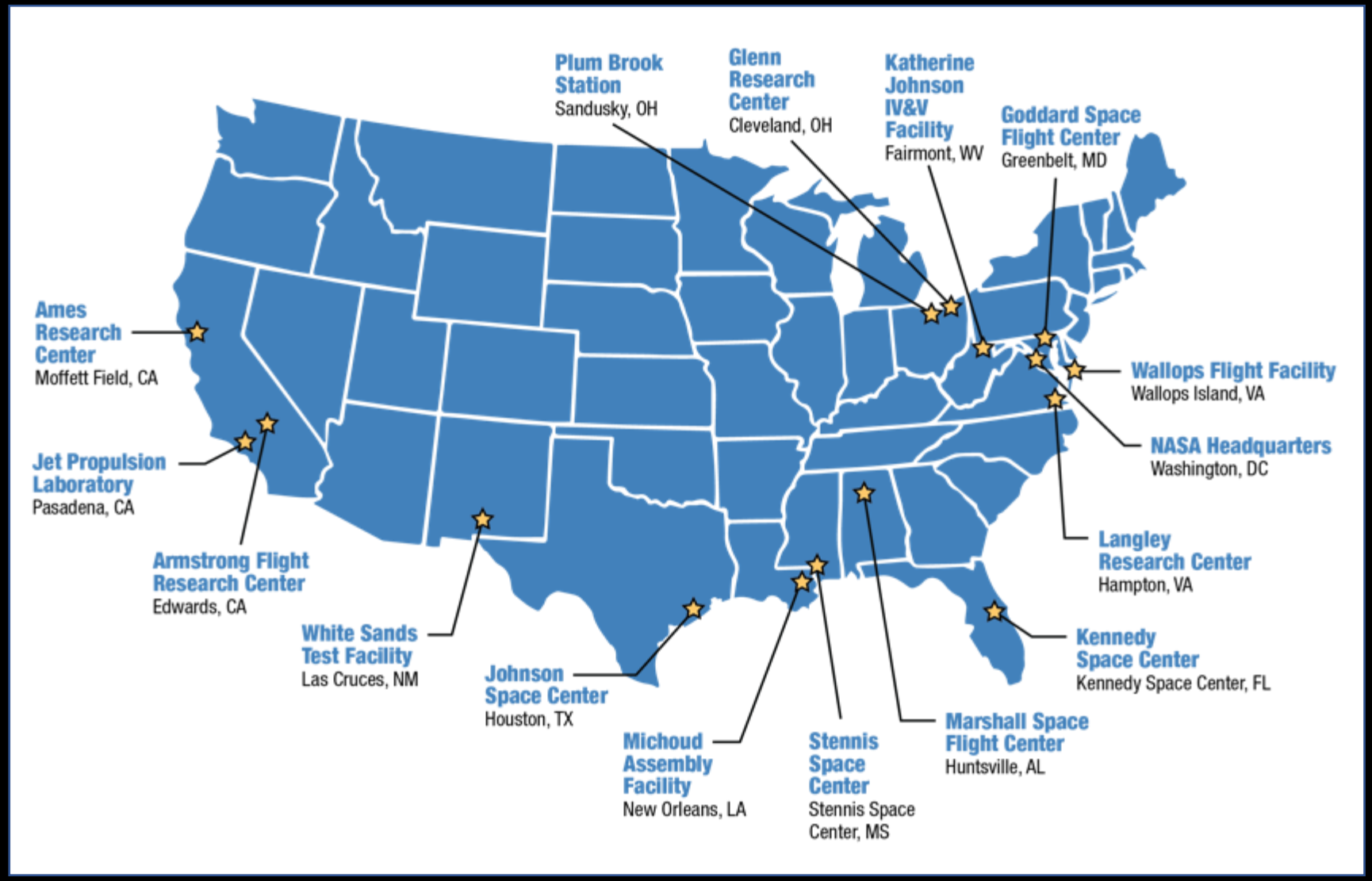
First Responders

NASA spinoff technologies:

- Save lives
- Make the planet cleaner
- Create jobs
- Educate and entertain
- Help small businesses
- And more



Every NASA Center Contributes to Artemis



Suppliers and small businesses across America have made contributions to the success of NASA's Artemis program.

Private companies are hard at work on innovations that will help establish a sustainable human presence at the Moon. The Artemis endeavor also extends beyond our borders.

For detailed information about NASA's partners and where to find them, visit the Artemis partners map at www.nasa.gov/content/artemis-partners

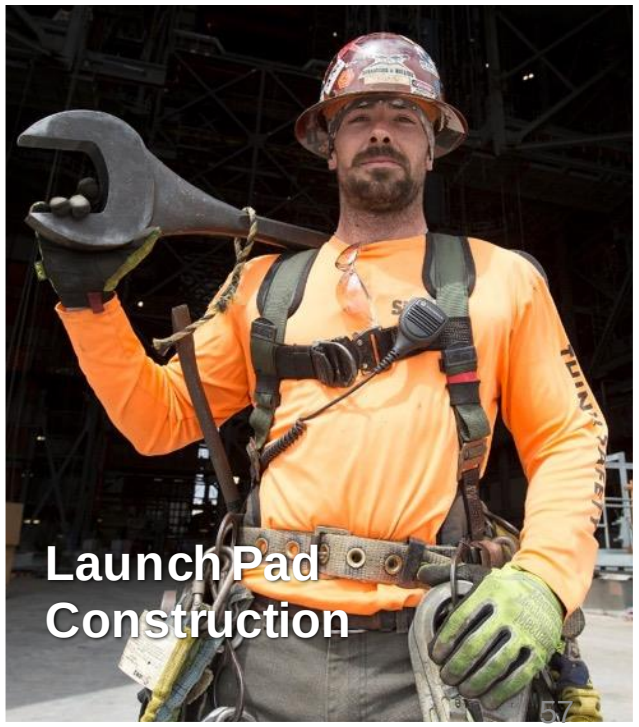

#NASAINTERNS


Welding
Technician


Avionics
Technician

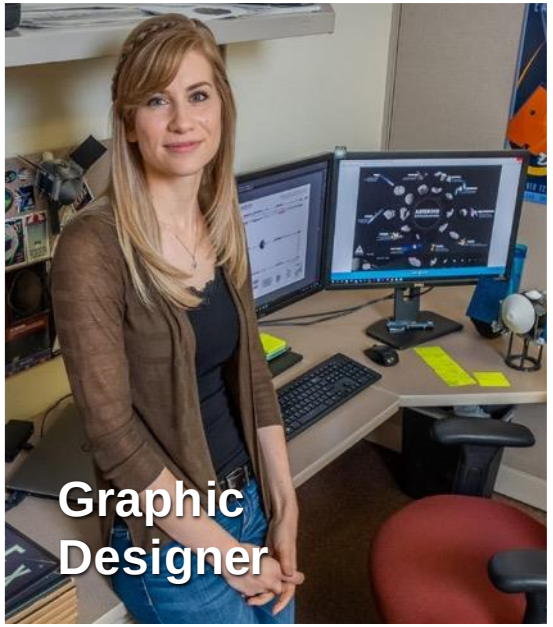

NASA
Food
Scientist


Mission Control Center
FLIGHT DIRECTOR
Flight Controller


Launch Pad
Construction


Social Media


Robotics Designer


Graphic
Designer


Astronaut
Trainer


Spacesuit
Designer


Geologist